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Light in the Sea.

By M. T. SPENCE, B.Sc.

DURING the past few years the scattering and absorption of light in gases and liquids has attracted a good deal of consideration and discussion. At one time it was thought that the scattering of light in the atmosphere was due only to the presence of dust particles, but the somewhat deeper blueness of the sky as seen from a mountain top in comparison with the colour as seen from lower altitudes contradicts this theory. The attenuation of light in the sea has also been ascribed to the presence of extraneous matter in suspension. It is within comparatively recent years that theory and experiment have shown adequately that the molecules of air and the molecules of water do themselves diffuse and absorb light to an extent which goes to explain the greater part of the observed phenomena.

Many years ago the late Lord Rayleigh* showed from theoretical considerations that in a direction at right angles to an incident beam of light the ratio of the intensity of the light scattered by molecules or particles, small compared with the wave length of light, is inversely proportional to the 4th power of the wave length. This result was arrived at from the theory of dimensions and did not depend on any particular theory regarding the nature of the molecules or the nature of light. (It appears doubtful whether these considerations still conform to the conceptions of modern physicists). In a later paper† he showed that, in the absence of dust, "the light scattered from the molecules (of air) would suffice to give us a blue sky not so very

* *Phil. Mag.* 41, 1871, p. 107.
† *Phil. Mag.* 47, 1899, p. 375.

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greatly darker than that actually enjoyed." The theory has been amply confirmed by the laboratory experiments of the present Lord Rayleigh,* who has shown that the magnitude of the scattering by dust-free gases is in agreement with the theory. During the past few years the values of atmospheric transmission co-efficients obtained at Mount Wilson Observatory go to prove that the amount of light scattered in the atmosphere is not greater than would be expected from Lord Rayleigh's consideration of molecular scattering. It appears, therefore, that the blueness of the sky is due to scattering by air molecules rather than by dust. It is also to be expected from Lord Rayleigh's considerations that the light scattered by water should belong essentially to the blue end of the spectrum. Professor Raman† has carried out an experimental investigation of molecular diffraction by water, using distilled water and tap water after repeated filtrations, and has found that " the track of the beam (of light passing through the water) viewed transversely was a blue colour, and it was judged that the greater part of the observed luminosity was probably due to the water itself." The quantitative results of the experiments agreed very closely with what was expected from the theory, and showed that water scattered light nearly 160 times as strongly as dust-free air. Professor Raman points out that the blueness of the sea is to be accounted for by the molecular diffusion of the water and is not due to reflected sky light, as was at one time believed, nor to the presence of particles in suspension.

It is evident, since light is scattered by the molecules of water in all directions that the intensity of light which emerges after passing through a layer of water will be a fraction of the incident light. For any wave length the intensity of illumination decreases with depth in accordance with the exponential law (ignoring the repeated diffraction of the light).

So far the only mode of decrease of intensity of illumination with depth to be considered, is that due to molecular scattering, but there is another factor of equal importance, absorption.

Absorption is the process whereby the energy of light vibration is transformed into heat energy. It has been established by experiment that the absorption of light by water is almost entirely confined to wave lengths longer than the green, and that the amount of absorption increases with increased wave length, *i.e.*, increases from the green towards the red. Green light would therefore suffer least decrease in intensity in penetrating the sea, whereas both red and blue light would be diminished relatively quickly, the red almost entirely by absorption, and the blue entirely by scattering.

* *Proc. R. Soc.* 94, 1918, pp. 453-458.
† *Proc. R. Soc.* 101, 1922, pp. 64-80.

In order to determine as accurately as possible the intensity of light at various depths in the ocean, Knudsen* designed an apparatus whereby photographs could be obtained simultaneously by two spectro-photometers at different depths. The quantitative comparison of the photographs is based on the principle that if, for any part of the spectrum, the amount of darkening shown on both plates is the same, then the intensities of illumination are inversely proportional to the widths of the slits used in the spectro-photometers.

Knudsen's results show that with increasing depth in the ocean the intensity of illumination decreases comparatively rapidly at the ends of the visible spectrum (*i.e.*, in the red and violet), and that the rate of decrease is least in the green portion of the spectrum. The number of observations discussed in the publication is too small to provide conclusive data, but the following table based on them is instructive :—

Wave length in Ångström units.	6500	6000	5500	5000	4500	4000
Depth in metres at which light is 1000 times weaker than on the surface	18	25	38	37	23	14
Fraction to which the intensity is reduced in passing through a layer of 10 metres	$\frac{1}{45}$	$\frac{1}{18}$	$\frac{1}{7}$	$\frac{1}{7}$	$\frac{1}{20}$	$\frac{1}{148}$

Knudsen does not state whether, in computing these results, he made any allowance for the time of day at which the photographs were taken. The instruments used were direct vision spectro-photometers, which renders the interpretation of the results difficult. In discussing the results, Knudsen writes : "The material is not large enough to warrant closer consideration here of the causes of absorption. It must suffice to note that it may be due partly to the presence of solid particles of varying size, partly to colouring matter in solution."

In view of the conclusions arrived at from the theoretical considerations and the experimental investigation of the extinction of light in passing through water, it appears probable that the attenuation observed by Knudsen is due mainly to scattering and absorption by the water molecules, and not to solid particles, nor to colouring matter in solution. Professor Raman states that the presence of organic matter would exercise a selective absorption in the blue region of the spectrum : this fact may account for the very rapid decrease in intensity found by Knudsen for 4000 A°. The presence of organic matter must be a factor of considerable importance. Sir John Murray, in "Depths of the Ocean," writes : "The enormous quantities of small plankton organisms inhabiting the upper layers may also render the water

* *Conseil Permanent International pour l'Exploration de la Mer. Publications de Circonstance.* No. 76.

relatively opaque." In discussing the extinction of light in the sea, Sir John Murray considers only the selective absorption of light, and deduces that the red light disappears much sooner than the blue, and that there must be many blue rays though hardly any red ones to a depth of 500 metres.

It has been pointed out that the blueness of the sea and the attenuation of light with increasing depth at the blue end of the spectrum are mainly due to molecular scattering. With reference to the scattering by solid particles and its effects, Professor Raman writes:—

> "(A) A very small quantity of finely dispersed matter would not appreciably alter either the colour or intensity; (B) a larger quantity of such matter would cause some increase in intensity, accompanied by a decrease in the saturation of the hue. Suspended matter not very finely dispersed would operate in a different way. The first effect of increasing size of the particles would be the breaking down of the λ^{-4} law* as regards the intensity of the light scattered in any given direction. With a collection of particles of different sizes the colour of the light scattered would be practically the same as the colour of the light incident on the particles in any given layer."

The blueness of the sea has been referred to, but no mention has been made of the greenness which the sea so frequently exhibits, particularly in shallow waters. Taking into consideration Professor Raman's deduction of what would happen with a collection of particles of different sizes, it appears evident that since the light incident at a depth of a few metres is predominant in the green, and since the light scattered upwards by the particles is again selectively absorbed and scattered, the greenness of the sea is to be ascribed to light scattered upwards by particles at the bottom or in suspension. This explanation of the greenness of the sea would lead one to anticipate that in deep waters the sea is nearly always blue, and that in shallow waters, which are not otherwise coloured by particles in suspension, the nature of the bottom might be determined by the blue or blue-greenness of the water, *e.g.*, with a bottom in parts dark rock and in parts white sand it should be possible to distinguish between the rock and sand by the blueness of the water over the former in contradistinction to the blue-greenness over the latter. Perhaps some reader will, from experience, confirm or contradict this deduction.

It is to be hoped that the Conseil Permanent International pour l'Exploration de la Mer will provide for systematic observations of the penetration of light into the sea. A knowledge of the variation with the seasons, as well as the variation from

* The law referred to is Lord Rayleigh's law that scattering varies inversely as the fourth power of the wave length.

place to place, would undoubtedly help to solve problems for biologists and for meteorologists. The life of the sea must be dependent to a large extent on the quantity of light reaching it. The amount of heat received from the sun by each layer in the ocean is a fundamental climatic factor.

The Line Squall of February 21st, 1923

By E. G. BILHAM, B.Sc.

ON February 21st a line squall of considerable violence passed across south-east England. The following notes were made by Mr. D. F. Bowering, the Observer at Biggin Hill, near Bromley, Kent :—

12h. 10m.	Anvil extension in WNW.
12h. 15m.	Slight shower with distant thunder.
12h. 35m.	Storm approaching from WNW; vivid lightning over Croydon.
12h. 45m.	Squall front running NE to SW, approaching from WNW.
12h. 50m.	Storm broke overhead with heavy thunder and some vivid lightning; hail, soft hail and heavy rain with slight sleet.
12h. 55m.	Mammamto-Cumulus forming in SE.
13h. 5m.	Wind veered to WNW and fell to 2 m.p.h., but increased suddenly to a squall of 35 to 40 m.p.h. just before front was overhead.
13h. 20m.	Precipitation ceased. Storm passing to east.
13h. 45m.	Hail shower and rainbow.

The sequence of events described by Mr. Bowering presents a number of interesting features. At first sight it might appear that the phenomena observed were simply those characteristic of the passage of a " cold front " similar to that described in the January number of the *Meteorological Magazine*. Actually, a much more complex series of changes occurred, the net result of which was to replace, temporarily, a cold south-easterly wind by a rather milder westerly current.

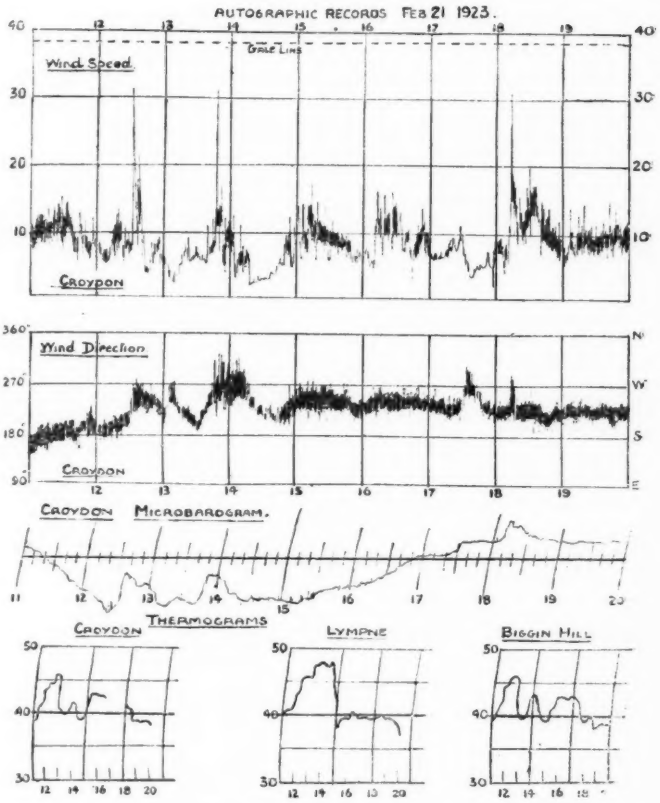
Before considering the details of the disturbance on February 21st it is necessary to recall the general conclusions regarding the thermal structure of cyclones which have been adopted at Bergen, chiefly as the result of investigations by J. Bjerknes and H. Solberg.* In its early stages a cyclone is found to consist of a wedge-shaped protusion, or sector, of warm " equatorial " air into a cold " polar " current. Usually the equatorial current flows from a south-westerly point, and the apex of the warm

* " Life Cycle of Cyclones and the Polar Front Theory of Atmospheric Circulation." *Geof. Publ. Krist.*, Vol. III., No. 1.

sector coincides with the centre of the depression. The direction of the polar current in front of the warm sector is normally south-easterly, while the current which follows in the rear of the warm air is from a point somewhere between west and north. Within a short period, often only a day or two, of the "birth" of the cyclone, the warm air near the centre gets cut off, or "secluded," as a result of the rapid advance of cold air from the rear. A further advance from the rear causes the secluded mass of warm air to rise, and very soon the warm sector entirely disappears from the chart. At this stage the cyclone is said to be "occluded," pressure begins to rise at the centre, and the cyclone "dies."

The latter half of February provided numerous opportunities of watching this process. A number of deep disturbances developed off our south-west coasts and moved across the British Isles. In each case they were initiated by a burst of warm air from the south-west, which very soon got cut off by polar air from the west. In most cases the disturbance died over the North Sea. The situation was controlled by two important factors: (A) a large stationary depression in the north-east Atlantic, which maintained a cold westerly current originating in high northern latitudes, and (B) an anticyclone covering Scandinavia and the Baltic, which maintained a strong south-easterly current over the North Sea and eastern England.

We now may turn to the actual position on the evening previous to February 21st. The 18h. chart showed the British Isles lying under a cold current mainly from the south-east, the temperature being below 40° F., except in the south-west corner where Scilly reported 46° F., with a south wind. A flow of warm air from south-west was shown at the Azores, where temperature had risen to 64° F. during the day. This warm air had reached Corunna, where rain was falling and the temperature was 55° F. The most striking feature of the chart was, however, a deep depression in the Atlantic centred about latitude 56° N, longitude 26° W. A Scandinavian ship near the centre reported a barometer reading of 951 mb. and wind west-south-west, force 9. The "Minnedosa," about 500 miles south of the centre, was experiencing a west wind of force 11, with heavy hail showers and a temperature of 46° F. (2° below the sea temperature). In these conditions the development of a secondary depression off our south-west coasts was to be expected, and the barometer was, in fact, falling briskly in that region. This secondary disturbance moved eastward across southern England during the day, but never developed closed isobars, and became occluded soon after it formed.



Records of Wind, pressure and temperature in South-east England, February 21st, 1923.

The phenomena at Biggin Hill were thus really incidents in the replacement of a south-east polar current in which the surface temperature was about 38° F. by a westerly polar current with a surface temperature of about 44° F. The rise to 46° F., which is shown on the thermograph trace at 12h. 30m., represents the last vestiges of the equatorial air. At a few points on the south coast the temperature in the tongue of equatorial air

exceeded 50° F.* The thunderstorms which occurred at Biggin Hill and other places were most probably due to the convergence of the two polar currents. Winter thunderstorms have been shown by E. V. Newnham† to be most frequently associated with a westerly polar current, and the observations on February 21st show that the storms occurred simultaneously with the arrival of such a current.

The most difficult phenomena to fit into the scheme are the alternations of temperature between 12h. 30m. and 16h. The sudden falls of temperature at about 12h. 50m. and 14h. are presumably to be attributed to the hail showers which occurred near those hours, but it is surprising that in each case it should have taken more than an hour for the temperature to recover the value characteristic of the general air current.

[* The warm air reached Shoeburyness, where the maximum for the day was 49° F., but not Clacton, where the maximum was 42° F.—Ed. *M.M.*]

Two Unusual Pilot Balloon Trajectories.

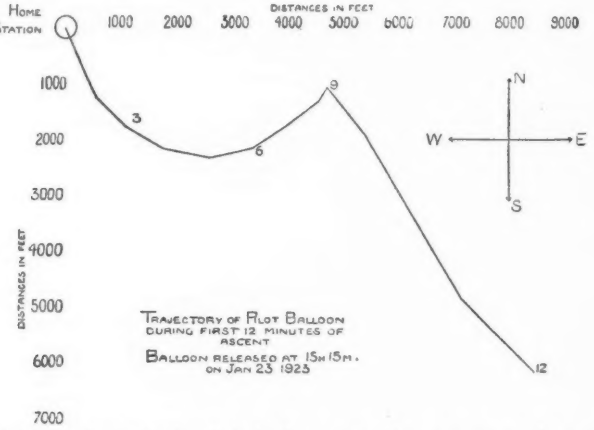
By Capt. D. Brunt, M.A., B.Sc.

In the course of tests made at Shoeburyness of two large theodolites, using special 150-inch pilot balloons, several very interesting ascents have been made and of these the two cases described below stand out on account of the rapid changes of wind noted in each case.

A pilot balloon was released at 15h. 15m. on January 23rd, 1923. An anticyclone was centred about 300 miles west of the mouth of the English Channel, with a depression centred north of Iceland. On the 7h. chart there was a fairly distinct line of discontinuity of surface temperature running down the west coast of Scotland, and across England to the Isle of Wight. The southernmost portion of this line was ill-defined on the 13h. chart. The interesting point concerning the pilot balloon ascent on this date is that it appears to have passed through a surface of discontinuity. A portion of the horizontal trajectory is reproduced in figure 1. The balloon started off in a south-easterly direction, and then swept round almost a complete semi-circle about the outstation, the wind backing to about south-west. During the eighth and ninth minutes the wind decreased without any considerable change of direction, then almost immediately after the ninth minute readings had been taken the balloon began to move very rapidly towards south-east, at about 24 miles per hour. No further marked change of wind velocity or direction was noted, though the balloon was

† *Meteorological Office Professional Notes*, No. 29.

followed to 20,000 feet. The balloon was found at a point about 230 miles south of Shoeburyness, having apparently followed the course of the isobars during the major portion of its journey. It was followed with two theodolites for 25 minutes, and afterwards with one theodolite for a further 17 minutes.



It is obvious that pilot balloon ascents near a surface of discontinuity require unusual watchfulness on the part of the observer. In this case the observer was watching the balloon at the instant when the sudden change of direction took place. Had the change taken place while the observer was reading the scales of the theodolite, it is practically certain that he could not have picked it up again. I suggest that this is possibly the cause of loss of many pilot balloons reported "burst." The decrease of the south-westerly wind occurs in a layer of the order of 1,000 feet in thickness, so that the term "surface," as applied to this change, requires a liberal interpretation. The extreme irregularity of the rate of ascent of the balloon is remarkable. The initial rate was well over 550 feet per minute. In the neighbourhood of the discontinuity it was only 450 feet per minute. In the 16th minute the balloon rose 800 feet, but in the 18th only 70 feet. The two-theodolite method affords two separate determinations of the height of the balloon, and so the computed heights can be accepted as being of a high order of accuracy.

The second pilot balloon ascent was made on March 12th, 1923, at 10h. 30m. The balloon revealed a south wind in the first 6,000 feet, then in the next 6,000 feet a wind from about south-east. At the 23rd minute, at a height of 12,300 feet, the balloon

changed its direction of motion, moving back towards south-east, showing a north-westerly wind. At about 15,000 feet the wind veered to north, and the remainder of the ascent shows a steady current from north up to 23,000 feet, at which height the balloon was lost.

A number of observations made on the same day confirm these results. Two balloons released at Shoeburyness at 11h. 50m. and at 14h. were picked up at distances of 150 miles and 24 miles respectively south of the station, and a balloon released at Lympne at 11h. was found at a point 240 miles south of that station. On the same day Croydon and Kew reported Cirrus moving rapidly from north, the former estimating a velocity of about 40 miles per hour. It thus appears that the northerly current may have persisted from a height of 12,000 feet up to the Cirrus level. A balloon released at Shoeburyness at 15h. 10m., and lost in cloud at 15,000 feet, showed a steady current from about south-south-west up to that height. On the same day an ascent at Calshot at 7h. showed a calm from 6,000 feet to 8,000 feet and a wind from north-north-west at 10,000 feet. The level of wind reversal appears therefore to have been lower further west.

The 7h. synoptic chart for March 12th shows a depression centred off the north-west of Scotland, with a fairly strong gradient for south-south-westerly winds over the greater part of the British Isles. There was a depression centred just south of Italy, and between this and an anticyclone centred over northern Russia there was a pronounced gradient for east-south-east winds. From the anticyclone a tongue of high pressure extended across the North Sea and south-east England, down to the north coast of Spain. Over south-east England winds were light and rather variable in consequence of the tongue of high pressure. The gradient of pressure between the Atlantic depression and the Russian anticyclone was fairly steep, the isobars running from south-south-west to north-north-east. By the next day the depression had moved away in a north-easterly direction, but the 7h. chart shows a secondary centred over the Isle of Wight. The temperature distribution shewn by the 7h. chart on the 12th consisted of a trough of low temperature extending in a north-south direction across England. This was apparently a local variation of the main distribution of temperature which indicated a decrease from west to east. A number of upper air temperatures were recorded, and they all show a transition from cold air at the surface to relatively warm air above, with a practically isothermal distribution from about 3,000 to 8,000 feet. These presumably give a transition from the relatively still air over the east of England to the southerly current in front of the Atlantic depression. An

ascent at Grain at 11h. 16m. shewed an adiabatic lapse rate from the surface to about 3,000 feet, then practically isothermal conditions up to 8,000 feet, after which the normal lapse rate for cyclones was followed up to about 15,000 feet. The measurements available apparently do not extend into the upper northerly current. The general distribution of decrease of temperature from west to east at the ground would tend to decrease the gradient of pressure at heights above the ground, and if the same general distribution of temperature held in the upper, would reverse the gradient at great heights.

No definite suggestion is here offered as to the origin of the northerly current, but the writer would emphasise the state of things, represented by this pilot balloon ascent, namely, a poleward circulation in the lower layers, with a circulation towards the equator in upper levels probably reaching into the stratosphere. It would have been of great interest to draw isobars for a height of 20,000 feet, had temperature observations been available in sufficient number to permit it. It will require the analysis of a large number of pilot balloon ascents to determine how far the state of things represented by the ascent of March 12th represents the normal interchange of air between equator and pole.

OFFICIAL NOTICE

The Circulation of Forecasts by Telephone

ARRANGEMENTS have been made by the Post Office, in conjunction with the Air Ministry, to communicate daily weather forecasts to the telephone exchanges throughout the country. For this purpose England, Scotland and Wales have been divided into some forty districts, so that each exchange may have available for subscribers information that will be appropriate to the area in which the exchange is situated. It is only necessary for telephone subscribers to ring up the operator at the local exchange at or after 5 p.m. to obtain the forecast for the following night and day.

No charge will be made beyond the local call fee (1¼d.), and in the case of rural "party-lines" no fee is payable. The forecast may be obtained also by ringing up from public call offices upon payment of the ordinary local call office fee.

The service, which was started on May 1st, is primarily intended for the use of farmers. The arrangements are provisional, and are to be reconsidered at the end of the Summer.

Royal Meteorological Society

THE monthly meeting of the Society was held on Wednesday, April 18th, at 49, Cromwell Road, South Kensington, Dr. C. Chree, F.R.S., President, in the chair.

W. H. Dines, F.R.S., and L. H. G. Dines, M.A.—An examination of British upper air data in the light of the Norwegian theory of the structure of the cyclone.

The theories of the Norwegian school of meteorologists, which have occupied so much attention during the last few years, were formulated without much reference to upper air observations, and the desirability of a scrutiny of such observations as are available is manifest. Such a scrutiny has been made by the authors of this paper, and the results are disappointing.

The first method adopted was to select from the occasions on which *ballon sonde* records were available, those on which the synoptic charts indicated that it was likely that the balloon had passed through the polar front. Graphs showing the relation of temperature to height were drawn for these occasions, and compared with graphs for other occasions selected more or less at random. It was found that there were no striking differences between the two groups, inversions of temperature occurring with about the same frequency.

A second problem, the relation between humidity and temperature, was attacked by utilising the kite ascents made at Pyrton Hill. It was found that an inversion of temperature was nearly always associated with a decrease in the humidity, whereas the Norwegian theory requires an increase.

The conclusion reached is that the observational evidence fails to support the hypothesis that the superposition of equatorial over polar air is a characteristic feature of the structure of a cyclone. The speakers who took part in the discussion showed great reluctance to accept this conclusion. Further examination of the material is evidently desirable.

Professor T. Kobayasi (Imperial University of Tokio).—On the mechanism of cyclones and anticyclones.

In this paper the structure of the lower layers of a cyclone is considered, and on certain simple assumptions the stream lines along which the air flows are plotted. The diagrams in which these are shown are very clear and suggestive. It is pointed out that in certain parts of the cyclone, currents flowing from quite different regions are brought into juxtaposition and overlap. If it happens that the upper current is much colder than the lower one the phenomenon characteristic of the line-squall will appear. The treatment of the anticyclone is very slight. The discussion brought out the fact that the treatment of the cyclone is kinematical not dynamical, it does not provide any explanation

for the fundamental phenomena which are described, but, in so far as the paper helps us to obtain a clear mental picture of the movements in three dimensions which characterize the cyclone, it will be a useful aid to the formulation of more comprehensive theories.

Capt. E. C. Shankland, R.N.R.—Notes on the fluctuations of mean sea-level in relation to change of atmospheric pressure.

The effect of meteorological conditions on the height of the tide is a matter of practical importance to harbour masters, and has received attention from many investigators. There are two factors to consider: the driving of the water before the wind causing high levels on the coast towards which the wind blows; and the direct effect of the pressure of the atmosphere to which the ocean responds like the mercury in a barometer. Capt. Shankland has selected observations made at Liverpool when the wind was slight, and has correlated with the atmospheric pressure the defect of high water below that predicted in the tide tables.

His conclusion is that the series of observations supports the hypothesis that the defect in the tide is about 20 times the excess above normal of the height of the mercury in the barometer.

In the discussion Mr. Durst pointed out that in the computation of the tides it was tacitly assumed that the average wind would blow. Now the average wind at Liverpool is onshore and tends to raise the tidal level, and, therefore, on a windless day the actual tide should be lower than the predicted tide. Mr. Durst thought it was better to take the depression of the sea level owing to atmospheric pressure as 13·6 times the rise of the barometer in accordance with hydrostatic theory, and to make separate allowance for the wind.

Correspondence

To the Editors, *The Meteorological Magazine*

Observations on "Atmospherics" at Cranwell

In view of the work now being done upon atmospherics and their meteorological causes by Mr. R. A. Watson Watt, Capt. Cave and others, the following observations notified to me by Flight-Lieut. I. Rodney, R.A.F., Officer in charge of the Wireless Telegraphy Station at Cranwell, may not be without interest.

Flight-Lieut. Rodney states that, on the 29th of March, he was at 15h. 55m. receiving on 450 metres wave length, and that then the atmospherics were of medium strength of the sort that give occasional crackles in the telephone receivers. At 16h. a faint hiss was audible, which gradually increased in strength until it became a positive roar in the receivers. The roar continued for an interval of approximately 15 minutes, when it gradually

diminished in strength to a fairly strong hiss, only to return within a very few minutes to another roar, this second phase lasting to 16h. 25m. roughly, when it gradually diminished, until at 16h. 30m. all was silent except for the well-known occasional crackles. The roar increased with increase of wave length up to 1,000 metres, remaining of the same intensity from thence up to 2,500 metres.

The interest of the observation is that several similar to it occurred last summer, and that from a wide experience Flight-Lieut. Rodney states that he has only heard it at Cranwell, and he is emphatic that the atmospherics experienced are peculiar. The meteorological conditions prevailing at the times of occurrence of this rare phenomenon have been noted by me, and in every case the outstanding feature is the presence of well-marked Cumulo-Nimbus clouds passing across, with or without rain or thunder phenomena, at the receiving station. Whilst this is all in accord with the belief enunciated by Mr. Watson Watt that atmospherics are very closely connected with convective processes in the atmosphere, it would be interesting to know whether this peculiar type is as peculiar as it is thought to be here, or whether Mr. Watson Watt or any other observers have noticed it, and, if so, as to whether it is, as it were, the wireless manifestation of the passage across of well-marked Cumulo-Nimbus clouds.

W. H. Pick.

R.A.F. (Cadet) College, Cranwell, Lincs., April 4th, 1923.

The phenomenon described in Captain Pick's letter is not of infrequent occurrence, and is, as he infers from his observations, generally associated with the passage of Cumulo-Nimbus cloud. It is caused by the flow of a fluctuating but more or less unidirectional current along the receiving antenna, under the very strong fields produced by the cloud charges. In the classification of atmospherics laid down by British Association Committee for radio-telegraphic investigations, this discharge is classed as "sizzle," and defined as "a buzzing or frying noise, often heard during a white squall." With an antenna insulated from earth by a small air gap, a stream of sparks several millimetres in length may often be produced across the gap in the conditions described. I have frequently observed similar discharges under a cloud sheet, which I am unable to classify, but which I should describe as a heavy sheet of a dull brown-grey tone with a characteristically "choppy" under-surface.

The Cranwell phenomena recall to my mind a very marked instance of exposed conductors under Cumulo-Nimbus cloud, which I described in a letter to *Nature* (1916, vol. xcvii., p. 161). Here sparks passed between the finger of the observer and a

Campbell-Stokes sunshine recorder on a concrete wall. The sparks increased in length and frequency as a Cumulo-Nimbus cloud reached the zenith, decreased and finally became indistinguishable as it receded, then reappeared with the approach of a second Cumulo-Nimbus, in close analogy with the Cranwell case.

The variation of loudness with wave-length, observed at Cranwell, is probably peculiar to the receiving circuits used. I should hazard a guess that tuning up to 1,000 metres had principally been effected by increasing inductance, which would give a greater variation of potential difference across the grid circuit, while tuning from 1,000 to 2,500 metres was carried out by adding capacity in parallel, which would not affect the potential differences produced by the comparatively slow fluctuations of aerial current.

R. A. WATSON WATT.

Radio Research Board Station, Aldershot, April 10th, 1923.

Meteorology and Folklore: The Aurora Polaris

"ONE wonders" wrote Captain R. F. Scott in his diary, "why history does not tell us of 'aurora' worshippers, so easily could the phenomenon be considered the manifestation of 'god' or 'demon'." The answer is not far to seek, for, unlike the other beautiful or terrifying phenomena of the atmosphere, the aurora is of limited range. In the southern hemisphere there is very little inhabited land in high latitudes; in the northern hemisphere the ancient lands around the Mediterranean enjoy a frequency of one in ten years. However, further north, legend has sprung up around the "Northern Lights."

To the American Indians, as Longfellow has recorded in "Hiawatha," they were:

> "The Death-Dance of the Spirits,
> Warriors with their plumes and war-clubs,
> Flaring far way to northward
> In the frosty nights of Winter;"

while on the other side of the Atlantic they are still called by the Scots "Na Fir Chlis," or the "nimble men." Another idea, especially as regards red auroræ, is that they are the reflection of bloodshed in a far country. Thus, in County Cork in 1854, a red aurora was said by the peasantry to be the blood shed at Balaclava; in 1868 it was remarked "I wonder can that be the blood of the Americans?"; while in 1870 a vivid manifestation was the "blood of the Frenchmen." According to the *Scottish Chronicle*, in the summer of A.D. 660 "the sky was seen to burn." This is probably a reference to a red aurora, probably of the kind which possibly inspired the poet of the Prose Edda, when he

described the Twilight of the Gods:

"The fire-reek rageth
Around Time's nurse,
And flickering flames
With heaven itself playeth."

Auroræ have actually been mistaken for terrestrial fires. Under Tiberius the legions ran to Ostia to extinguish a fire which only existed in the heavens, while during the recent war an aurora which appeared during an air raid, led the inhabitants of Dover to think that Canterbury was in flames. The aurora is believed to be the same as a rare appearance called "Buddha's lights" by the Cingalese. This is said by the priests to be a sign of Buddha's anger with sinners, and to appear over the "wihare" where the offenders last worshipped.

Truly the aurora is a lovely enigma. It appears in regions where Nature is not over-lavish with her beauties. Its exact cause is still doubtful, and is still a challenge to the intellect. It is a fitting manifestation of that most elusive force, electricity and its ally magnetism, and, as Captain Scott said, "a golden writing which we have not the key to decipher."

CICELY M. BOTLEY.

10, *Wellington Road, Hastings, April 21st*, 1923.

[Authentic observations of red auroræ, at any rate as far south as the British Isles, are rare. The inexperienced observer is apt to report the red glow when the sun is beyond the northern horizon in the middle of a summer night as "Northern Lights" or "aurora."—ED. *M.M.*]

Peculiar Solar Phenomenon

AT 19h. 8m. on Thursday, March 19th, I observed the sun's disc taking a rather peculiar shape while setting in the west. As it sank behind a layer of alto-stratus cloud its lower limb, which projected beneath the cloud, appeared flattened out and enlarged, whilst the upper limb took the form of a cone, with the result that for a few seconds the sun appeared like a burnished triangle with the cloud intercepting the upper from the lower limb.

The sky at the time was practically overcast (9) with alto-cumulus and alto-stratus clouds and a slight east-north-east breeze (force 2) prevailed, the atmosphere being hazy and the air cold. I am of the opinion that the distortion of the sun's disc in this case was caused by refracted light owing to the density of the air surrounding the alto-stratus cloud layer.

CHARLES F. PRIESTLEY.

49, *Brisbane Street, Greenock, April 30th*, 1923.

[The theory of such phenomena given by Wegener in *Annal. d. Physik.* iv. Folge, Bd. 57, 1918, is discussed by Exner in the second edition of the *Meteorologicische Optik*, p. 158.—ED. *M.M.*]

NOTES AND QUERIES

Monthly Weather Report, 1923

CONSIDERABLE changes have been made in the form of the Monthly Weather Report commencing with the January issue of this year. The principal differences are in the table (Table IV.) devoted to the summary of observations at fixed hours, and tend to facilitate the study of the daily variation in weather conditions. Thus, in the case of pressure, we now have the mean pressure at each of the specified hours instead of the mean for the 24 hours (incidentally the practice of putting pressure at station level as well as at sea level has been dropped except in the case of a few stations at considerable heights). The frequency with which various fractions of the sky are cloud-covered is now given for each hour of observation, a plan which it is thought will be much more useful than the old one of stating the frequency with which the average cloudiness at two or three hours falls within certain limits.

A new departure is the inclusion of a summary of the observations of visibility in the table. These observations have become of great interest in recent years, not only in connection with aviation but because of their bearing on the study of atmospheric pollution and of atmospheric electricity, and having them set out in permanent tables should facilitate comparisons between different parts of the country.

The increase in the amount of space allotted to each station has unfortunately necessitated a reduction in the number included in Table IV. It is hoped, however, that in some cases statistics on the same lines will be computed and published locally.

The notes on the tables, now set out on a single page, should facilitate the use of the Report.

A Floating Weather Bureau

MR. E. H. BOWIE, of the United States, Weather Bureau, paid a short visit to the Meteorological Office at the beginning of March. He had interesting news to give us. He had come from America in the French vessel *Jacques Cartier*, which sails between Antwerp and New Orleans touching at a French port en route. The vessel is one of about 20,000 tons and is used as a training ship for cadets of the French Mercantile Marine. It carries a cargo to help pay for the cost of using so large a vessel as a moving training ship.

The cadets are taught ordinary climatology and methods of meteorological observation as cadets for the Mercantile Marine have been in the past, but, in addition to this, an endeavour is

being made to instruct them in the methods and utility of synoptic meteorology under the varying conditions which they experience in voyaging between France and New Orleans.

During his voyage on the *Jacques Cartier* Mr. Bowie collected reports by wireless telegraphy from many ships in the Atlantic and from shore stations, drew synoptic charts from the observations, and issued forecasts for the information of the ships which had co-operated. The *Jacques Cartier* was in the words of the *Philadelphia Public Ledger* "a floating weather bureau."

Even before the war scientific meteorologists were aware of the possibility of extending synoptic meteorology to ships at sea owing to the development of radio-telegraphy. A beginning had even been made. Reports were being collected from ships and issued to ships. Experience during the war showed that an extension of this was not merely a possibility but practically a necessity; and all meteorologists will welcome the enterprise which the French Mercantile Marine has shown in securing the co-operation of the French Meteorological Office in this useful work, and, what is perhaps more important, in securing for their cadets, at an age when they are most open to impression, contact with expert meteorologists and an opportunity of learning the use of a weather map during a voyage at sea.

A Solarphysics Observatory for Central Australia

NEARLY twenty years ago a movement was started for establishing an astronomical observatory in the dry clear atmosphere of central Australia, and in 1908 a committee was appointed by the British Association for this purpose. The Commonwealth Government supported the scheme, and, during the British Association meeting in Australia in 1914, the Prime Minister of the Commonwealth consented to receive a deputation of overseas astronomers on the solar work to be undertaken in Australia. The expedition sent out by the Lick Observatory to observe the solar eclipse on September 21st, 1922, in central Australia, has also given an impetus to the scheme.

The suggested site is Alice Springs, where the average cloudiness at night is two-tenths and the visibility exceptionally good. The Australian Government Astronomer (Mr. G. F. Dodwell), who is strongly in favour of the idea, reports that from Moorilyanna he could see with binoculars Mount Ferdinand, 64 miles distant. Another report from the same district states that a smoke column from a train 45 miles away was seen through the theodolite telescope, and by the movement of the smoke the shunting of the train could be observed. At Cordillo Downs, where they used large instruments lent from America, they noted the perfect definition of the sun, moon and corona.

Mr. Dodwell is appealing both to Governments and to private enterprise for endowments and instruments for the proposed astronomical observatory in central Australia. He reminds us that the Observatories of Europe and America are indebted to private munificence as well as to Government aid.

Meteorological Course at Kew Observatory

THE meteorological course referred to on p. 5 of the February issue was held at Kew Observatory during the week April 23rd—28th. Nine observers from municipal stations at Health Resorts and one private observer were present. The instructor was Captain E. W. Barlow, of the Climatology Division, Meteorological Office. A number of special visits were arranged, the party being shown over Kew Observatory, the Offices at Kingsway and South Kensington and Croydon Aerodrome.

A Prayer for Rain

A PAPER on *The Alps of Chinese Tibet* was read by Prof. J. W. Gregory before the Royal Geographical Society on December 11th, 1922. In the discussion which followed, the President, Sir Francis Younghusband, revealed his experience of floods in Western China some years ago*. "On this occasion," he said, "the gates at Chung-King were closed, not in order to keep out the evil spirits who brought the flood, but in order to keep out the evil spirits who prevented the flood from rising, because the country had been suffering from drought. The magistrate of the city was ordered to repair to the various temples and to pray for rain. He prayed in one of the temples on August 5th in the year 1906 and he prayed with prodigious effect. It began to rain, and a waterspout within twelve hours burst a little higher up the river. The result was disastrous. The river at Chung-King rose to the almost unprecedented height of 108 feet. Houses, coffins, corpses, and live freight on various forms of support were seen racing down the river and were watched in their mad career by the inhabitants on the city wall."

News in Brief

We learn with regret of the death, on May 3rd, of Captain Carl Ryder, Director of the Danish Meteorological Institute.

The discourse entitled "The Water in the Atmosphere," delivered by Dr. G. C. Simpson, C.B.E., F.R.S., at the Royal Institution on March 2nd, was published as a supplement to *Nature* for April 14th.

* See *The Geographical Journal*, March, 1923, *p.* 178.

It is announced that Dr. Charles Niven, F.R.S., for many years Professor of Natural Philosophy in the University of Aberdeen, died on May 11th, 1923.

Meteorological Office—Staff News. On Monday, April 30th, a team representing the Meteorological Office defeated, by 3 goals to 2, a team representing the Aeronautical Inspection Department in the final round for the Air Ministry Football Cup. At the close of the match Dr. Simpson presented the Cup to the Office team on behalf of the Air Ministry, and expressed his great pleasure that the Office had done so well.

The Weather of April, 1923

DURING the first few days of the month pressure was high over Scandinavia and low over the Atlantic and the Bay of Biscay, so that a general southerly wind current prevailed over the British Isles and the temperature rose to 60° F. or slightly higher in the midland and southern counties. 60° F. was also exceeded in the same districts on the 11th and 12th, when the pressure distribution was somewhat similar. Thunder was heard generally about this time. Between these two warm periods the Scandinavian high spread westwards towards Iceland causing easterly winds to prevail over the whole of central Europe and the British Isles. These winds were strong in force along the east coast of England on the 8th and 9th and were accompanied by slight showers of snow in London and many other places.

An easterly type of weather prevailed from the middle of the month until about the 25th, when there was a change to a warmer south-westerly type, and gales occurred in parts of the English Channel on the 25th. High winds and gales were also reported from the Shetland Isles about this period, and snow or sleet fell in various parts of Scotland between the 23rd and 27th. During the latter part of the month ground frost occurred repeatedly, and in a few instances frost was also recorded by instruments in the screen, *e.g.*, 24° F. was reported from Eskdalemuir on the night of the 27th—28th. Sunshine was generally rather poor, and in some instances only amounted to about three-quarters of the average ; at Aberdeen the total was as low as 90 hours.

The general rainfall in the British Isles, expressed as a percentage of the average, was : England and Wales, 126 ; Scotland, 126 ; Ireland, 139 ; British Isles, 128.

Weather Abroad, April, 1923

THE month was marked by several spells of severe weather in western Europe. On the 10th unusual cold was reported in Andalusia, with snow in Granada, and fog at Seville. On the

18th the vineyards in the Palatinate (south-west Germany) suffered severely from frost, and about the same date there were heavy falls of snow in the Swiss Alps. Towards the close of the month heavy snow fell in the Belgian Ardennes. In the North Atlantic the ice conditions were severe, and the *Blutha* was caught in drift ice and abandoned in 41 N, 47 W, far outside the usual ice limits.

In North America on the night of April 4th to 5th there were tornadoes in Lousiana, North Carolina and Texas, with heavy rain and hail storms in various places, associated with a depression which moved south-eastward from the Pacific coast to northern Texas and thence north-eastward. After that the weather in the eastern States was mainly dry, and towards the close of the month forest fires occurred. In Canada there was still much ice on the rivers.

On the 14th a telegram from Cairo stated that while the level of the Mountain Nile was abnormally low, heavy rains in north-west Abyssinia had caused considerable rises in the level of the Sabat River and the Upper Blue Nile. These should restore the main river to its normal level for the time of year, and irrigation prospects are promising.

On the 21st heavy rains were reported in Western Australia, and on the 23rd light rains fell in parts of Victoria and the Riverina district, but there was no general break up of the weather in the east.

The end of March and the beginning of April were marked by a severe storm in the Cordoba district (Argentine), in which over 130 mm. of rain fell in about thirty-six hours. The rivers overflowed and rendered many people homeless. On the night of April 8th Bahia Blanca was flooded by a heavy sea swell, which partially destroyed the sea wall. The weather was fine and calm at the time.

The special message from Brazil states that the rainfall has been very irregular all over the country, but on the average was in excess of the normal. There has been a very active circulation of small highs in the south and centre with temperature well above the normal. Coffee and cotton prospects are excellent. At Rio de Janeiro pressure was 3·9 mb. above normal, and temperature 2·3° F. above normal.

Rainfall Table for April, 1923

CO.	STATION.	In.	mm.	Per-cent. of Av.	CO.	STATION.	In.	mm.	Per-cent. of Av.
Lond.	Camden Square.....	1·37	35	89	*Leics*	Leicester Town Hall...	1·59	40	...
Sur .	Reigate, Hartswood...	2·36	60	...	,, .	Belvoir Castle.....	1·70	43	111
Kent.	Tenterden, View Tower	2·06	52	127	*Rut* .	Ridlington.....	1·82	46	...
,, .	Folkestone, Boro. San.	...	...	...	*Linc.*	Boston, Skirbeck	·85	22	63
,, .	Broadstairs	...	...	...	,, .	Lincoln, Sessions House	·93	24	67
,, .	Sevenoaks, Speldhurst.	2·46	63	...	,, .	Skegness, Estate Office.	·86	22	64
Sus .	Patching Farm.....	3·88	99	222	,, .	Louth, Westgate	1·20	31	72
,, .	Eastbourne, Wilm. Sq.	2·14	54	118	,, .	Brigg	1·54	39	98
,, .	Tottingworth Park....	3·54	90	...	*Notts.*	Worksop, Hodsock....	1·71	43	116
Hants	Totland Bay, Aston...	3·39	86	207	*Derby*	Mickleover, Clyde Ho..	2·08	53	120
,, .	Fordingbridge, Oaklnds	3·76	95	205	,, .	Buxton, Devon. Hos...	3·93	100	134
,, .	Portsmouth, Vic. Park.	3·19	81	203	*Ches.*	Runcorn, Weston Pt...	2·70	69	156
,, .	Ovington Rectory	3·60	91	190	,, ..	Nantwich, Dorfold Hall	1·93	49	...
,, .	Grayshott	3·51	89	179	*Lancs*	Bolton, Queen's Park .	3·67	93	...
Berks	Wellington College...	2·60	66	161	,, ..	Stonyhurst College....	3·63	92	134
,, .	Newbury, Greenham..	3·03	77	166	,, ..	Southport, Hesketh...	...	...	...
Herts.	Bennington House....	1·57	40	103	,, ..	Lancaster, Strathspey.	3·13	79	...
Bucks	High Wycombe	2·70	69	172	*Yorks*	Sedbergh, Akay	5·49	139	169
Oxf..	Oxford, Mag. College..	2·19	56	142	,, .	Wath-upon-Dearne ...	2·10	53	133
Nor .	Pitsford, Sedgebrook..	1·64	42	107	,, .	Bradford, Lister Pk...	2·31	59	115
,, .	Eye, Northolm.....	·94	24	...	,, .	Oughtershaw Hall	5·92	150	...
Beds.	Woburn, Crawley Mill.	1·75	45	117	,, .	Wetherby, Ribston H..	1·80	46	102
Cam.	Cambridge, Bot. Gdns.	1·16	29	85	*ERY*	Hull, Pearson Park ...	1·53	39	98
Essex	Chelmsford, CountyLab	·85	47	...	,, .	Holme-on-Spalding ...	1·44	37	...
,, .	Lexden, Hill House...	1·06	27	...	,, .	Lowthorpe, The Elms.	1·53	39	92
Suff.	Hawkedon Rectory ...	1·33	34	86	*NRY*	West Witton, Ivy Ho..	3·25	83	...
,, .	Haughley House.....	·79	20	...	,, .	Pickering, Hungate ...	1·61	41	...
Norf.	Beccles, Geldeston....	·55	14	37	,, .	Middlesbrough	1·31	33	96
,, .	Norwich, Eaton	1·09	28	64	,,	Baldersdale, Hury Res.	2·80	71	119
,, .	Blakeney	1·09	28	85	*Durh.*	Ushaw College	1·70	43	90
,, .	Swaffham	·94	24	64	*Nor* .	Newcastle, Town Moor.	2·04	52	124
Wilts.	Devizes, Highclere....	2·36	60	...	,, .	Bellingham Manor....	2·23	57	...
Dor .	Evershot, Melbury Ho.	2·46	63	104	,, .	Lilburn Tower Gdns...	2·15	55	119
,, .	Weymouth, Westham..	3·00	76	181	*Cumb.*	Penrith, Newton Rigg..	3·04	77	145
,, .	Shaftesbury, Abbey Ho.	2·88	73	135	,, .	Carlisle, Scaleby Hall .	1·01	25	52
Devon	Plymouth, The Hoe...	3·04	77	138	,, .	Seathwaite	8·10	206	109
,, .	Polapit Tamar	3·14	80	134	*Glam.*	Cardiff, Ely P. Stn.....	3·68	93	145
,, .	Ashburton, Druid Ho..	5·50	140	180	,, .	Treherbert, Tynywaun	6·20	157	...
,, .	Cullompton	2·72	69	120	*Carm*	Carmarthen Friary....	2·97	75	108
,, .	Sidmouth, Sidmount ..	2·56	65	120	,, .	Llanwrda, Dolaucothy.	4·38	111	133
,, .	Filleigh, Castle Hill ...	2·89	73	...	*Pemb*	Haverfordwest, Portf'd	3·29	84	126
,, .	Hartland Abbey.....	2·12	54	...	*Card.*	Gogerddan.....	3·77	96	144
Corn.	Redruth, Trewirgie ...	4·28	109	149	,, .	Cardigan, County Sch. .	2·64	67	...
,, .	Penzance, Morrab Gdn.	3·62	92	149	*Brec.*	Crickhowell, Talymaes	4·00	102	...
,, .	St. Austell, Trevarna..	3·94	100	140	*Rad* .	Birm. W.W. Tyrmynydd	4·46	113	121
Som	Street, Hind Hayes ...	1·78	45	...	*Mont.*	Lake Vyrnwy	...	...	...
Glos..	Clifton College	2·87	73	133	*Denb.*	Llangynhafal	1·42	36	...
,, .	Cirencester	2·73	69	142	*Mer* .	Dolgelly, Bryntirion..	4·61	117	126
Here.	Ross, County Obsy. ...	2·43	62	129	*Carn.*	Llandudno	1·75	45	97
,, .	Ledbury, Underdown.	2·61	66	...	,, .	Snowdon, L. Llydaw 9	10·95	278	...
Salop	Church Stretton.....	2·99	76	138	*Ang* .	Holyhead, Salt Island.	2·58	66	124
,, .	Shifnal, Hatton Grange	2·19	56	130	,, .	Lligwy	3·04	77	...
Staff.	Tean, The Heath Ho...	2·65	67	133	*Man.*	Douglas, Boro' Cem...	2·72	69	110
Worc.	Ombersley, Holt Lock.	...	...	...	*Guer.*	St. Peter Port, Grange.	2·73	69	136
,, .	Blockley, Upton Wold.	2·90	74	149	*Wigt.*	Stoneykirk, Ardwell Ho	2·87	73	137
War	Farnborough.....	2·59	66	132	,, .	Pt. William, Monreith .	2·68	68	...
,, .	Birminghm, Edgbaston	2·49	63	143	*Kirk.*	Carsphairn, Shiel.	3·96	101	...

Rainfall Table for April, 1923—*continued*

CO.	STATION.	In.	mm.	Per-cent. of Av.	CO.	STATION.	In.	mm	Per-cent. of Av.
Kirk.	Dumfries, Cargen.....	5·06	129	190	*Caith*	Loch More, Achfary...	3·65	93	75
Dum	Drumlanrig	4·30	109	175	,, ..	Wick	2·74	70	138
Roxb	Branxholme	2·85	72	151	*Ork.*	Pomona, Deerness	3·19	81	154
Selk.	Ettrick Manse.....	4·74	120	...	*Shet.*	Lerwick	1·76	45	77
Berk.	Marchmont House	1·63	41	81	*Cork.*	Caheragh Rectory	6·69	170	...
Hadd	North Berwick Res....	1·98	50	141	,, ..	Dunmanway Rectory.	7·68	195	185
Midl	Edinburgh, Roy. Obs..	1·79	45	131	,, ..	Ballinacurra	4·36	111	168
Lan.	Biggar	3·30	84	191	,, ..	Glanmire, Lota Lo. ...	4·71	120	168
Ayr.	Kilmarnock, Agric. C..	2·80	71	136	*Kerry*	Valencia Obsy.	...	...	...
,, .	Girvan, Pinmore.....	...	...	...	,, .	Gearahameen	8·60	218	...
Renf.	Glasgow, Queen's Pk..	3·21	81	163	,, .	Killarney Asylum.....	5·06	129	153
,, .	Greenock, Prospect H..	4·75	121	130	,, .	Darrynane Abbey	3·48	88	101
Bute.	Rothesay, Ardencr'g..	3·92	100	132	*Wat.*	Waterford, Brook Lo..	4·00	102	157
,, .	Dougarie Lodge	3·81	97	...	*Tip.*	Nenagh, Cas. Lough...	3·30	84	131
Arg.	Glen Etive.....	...	...	...	,, .	Tipperary	3·51	89	...
,, .	Oban	3·47	88	...	,, .	Cashel, Ballinamona ..	3·24	82	130
,, .	Poltalloch	3·63	92	124	*Lim.*	Foynes, Coolnanes	4·11	104	168
,, .	Inveraray Castle.....	3·50	89	76	,, .	Castleconnell Rec.	3·61	92	...
,, .	Islay, Eallabus.....	3·29	84	115	*Clare*	Inagh, Mount Callan ..	6·02	153	...
,, .	Mull, Benmore	2·30	58	...	,, .	Broadford, Hurdlest'n.	3·76	95	...
,, .	Mull, Quinish	...	...	...	,, .	Newtownbarry	4·30	109	...
Kinr.	Loch Leven Sluice	3·45	88	180	*Wexf*	Gorey, Courtown Ho...	3·50	89	160
Perth	Loch Dhu	6·10	155	129	*Kilk.*	Kilkenny Castle	3·45	87	158
,, ..	Balquhidder, Stronvar.	3·87	98	87	*Wic.*	Rathnew, Clonmannon	3·55	90	...
,, ..	Crieff, Strathearn Hyd.	3·59	91	164	*Cars.*	Hacketstown Rectory .	3·01	77	114
,, ..	Blair Atholl.....	3·16	80	152	*QCo.*	Blandsfort House.....	3·16	80	121
,, .	Coupar Angus School..	2·54	65	153	,,	Mountmellick	3·17	81	...
Forf.	Dundee, E. Necropolis.	2·61	66	154	*KCo.*	Birr Castle.....	2·91	74	135
,, .	Pearsie House.....	3·95	100	...	*Dubl.*	Dublin, FitzWm. Sq...	3·13	79	165
,, .	Montrose, Sunnyside..	2·31	59	127	,, .	Balbriggan, Ardgillan .	3·56	90	180
Aber.	Braemar Bank	2·23	57	97	*W.M*	Athlone, Twyford.....	...	...	...
,, .	Logie Coldstone Sch. ..	2·39	61	119	,, .	Mullingar, Belvedere .	...	...	...
,, .	Aberdeen, Cranford Ho	2·26	57	110	*Long*	Castle Forbes Gdns....	2·38	61	100
,, .	Fyvie Castle	2·57	65	...	*Gal.*	Galway, Waterdale ...	2·59	66	...
Mor.	Gordon Castle.....	1·73	44	99	,, .	Woodlawn	...	...	...
,,	Grantown-on-Spey....	2·19	56	111	*Mayo*	Crossmolina, Enniscoe	4·47	113	142*
Na.	Nairn, Delnies.....	1·92	49	128	,, .	Mallaranny.....	4·09	104	...
Inv..	Ben Alder Lodge	2·73	69	...	,, .	Westport House.....	2·46	63	91
,, .	Kingussie, The Birches	1·99	51	...	,, .	Delphi Lodge	7·76	197	...
,, .	Fort Augustus	2·19	56	86	*Sligo*	Markree Obsy.	3·05	77	116
,, .	Loch Quoich, Loan....	4·50	114	...	*Ferm*	Enniskillen, Portora ..	3·13	79	...
,, .	Glenquoich	3·72	95	57	*Arm.*	Armagh Obsy.	3·16	80	150
,, .	Inverness, Culduthel R.	...	...	...	*Down*	Warrenpoint	4·71	120	...
,, .	Arisaig, Faire-na-Squir	...	...	...	,, .	Seaforde	4·63	118	177
,, .	Fort William.....	3·85	98	87	,, .	Donaghadee	3·04	77	152
,, .	Skye, Dunvegan.....	2·91	74	...	,, .	Banbridge, Milltown .	2·93	74	143
,, .	Barra, Castlebay	2·64	67	...	*Antr.*	Belfast, Cavehill Rd. ..	3·74	95	...
R&C	Alness, Ardross Cas. ..	3·99	101	165	,, .	Glenarm Castle.....	3·69	94	...
,, .	Ullapool.....	2·66	68	...	,, .	Ballymena, Harryville	3·37	86	128
,, .	Torridon, Bendamph..	3·93	100	75	*Lon.*	Londonderry, Creggan	2·85	72	111
,, .	L. Carron, Plockton...	3·29	84	...	*Tyr.*	Donaghmore	4·13	105	...
,, .	Stornoway	2·99	76	99	,, .	Omagh, Edenfel	4·17	106	159
Suth.	Dunrobin Castle.....	...	...	...	*Don.*	Malin Head	2·58	66	131
,, .	Lairg	3·23	82	...	,, .	Letterkenny Hos	3·47	88	124
,, .	Forsinard	...	...	...	,, .	Dunfanaghy	2·68	68	99
,, .	Tongue Manse.....	4·22	107	161	,, .	Narin, Kiltoorish	2·73	69	...
,, .	Melvich School.....	2·20	56	95	,, .	Killybegs, Rockmount.	3·60	91	100

* Enniscoe for Jan. 6·50 in., Feb. 8·65 in., March 4·23 in.

Climatological Table for the British Empire, November, 1922

STATIONS	PRESSURE		TEMPERATURE							Relative Humidity	Mean Cloud Am'nt	PRECIPITATION			BRIGHT SUNSHINE	
			Absolute		Mean Values				Mean							
	Mean of Day M.S.L.	Diff. from Normal	Max.	Min.	Max.	Min.	½ max. and min.	Diff. from Normal	Wet Bulb.			Am'nt	Diff. from Normal	Days	Hours per day	Percentage of possible.
	mb.	mb.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	%	0—10	mm.	mm.			
London, Kew Obsy.	1023·3	+ 8·8	55	29	48·0	36·9	42·5	— 1·5	41·3	84	7·5	36	— 20	8	1·3	15
Gibraltar	1019·9	+ 3·4	72	47	65·6	57·5	61·5	+ 1·6	57·1	76	5·4	102	— 59	8	...	...
Malta	1016·6	+ 0·9	76	45	64·0	57·6	60·8	— 2·3	56·0	77	6·2	48	— 33	12	4·1	40
Sierra Leone	1011·5	+ 0·7	91	71	87·2	73·7	80·5	— 0·7	75·5	76	6·5	181	+ 47	21	...	...
Lagos, Nigeria	1010·0	— 0·8	89	71	87·2	75·2	81·2	— 0·1	78·2	76	7·9	89	+ 23	9	...	...
Kaduna, Nigeria	1010·3	— 1·0	95	67	90·4	72·0	81·2	+ 6·2	68·0	49	...	0	— 1	0	...	...
Zomba, Nyasaland	1008·2	— 0·8	99	60	89·8	67·4	78·6	+ 3·5	...	88	4·5	90	— 52	16	...	...
Salisbury, Rhodesia	1007·7	— 2·3	92	56	84·9	61·1	73·0	+ 2·1	64·4	58	5·4	165	+ 73	14	...	...
Cape Town	1015·2	— 0·5	93	48	74·6	56·0	65·3	+ 2·2	61·5	65	5·2	11	— 16	7	...	...
Johannesburg	1011·3	— 1·0	81	45	73·5	52·6	63·1	— 0·3	55·2	67	4·2	133	+ 25	16	8·4	63
Mauritius	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Bloemfontein	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Calcutta, Alipore Obsy.	1013·1	— 0·2	86	56	83·0	64·4	73·7	+ 0·6	64·6	74	3·1	2	— 12	*0	...	...
Bombay	1010·6	— 1·3	92	68	88·6	75·2	81·9	+ 1·6	71·6	71	2·6	0	— 10	*0	...	...
Madras	1010·2	— 1·1	88	65	83·7	73·7	78·7	0·0	75·1	85	7·6	834	+509	*19	...	...
Colombo, Ceylon	1010·3	+ 0·2	88	69	84·8	73·5	79·1	— 1·2	75·8	74	7·4	545	+238	21	...	...
Hong Kong	1018·3	+ 0·7	83	44	74·1	63·4	68·7	— 1·0	60.3	59	5·0	14	— 22	4	6·6	60
Sandakan	...	...	89	73	87·0	75·3	81·1	+ 0·1	76·8	77	...	337	— 36	14	...	...
Sydney	1011·7	— 2·0	99	52	77·7	59.5	68·6	+ 1·6	61·3	55	4·4	9	— 64	5	8·2	60
Melbourne	1012·7	— 1·5	96	39	71·6	50·2	60·9	— 0·4	55·3	54	5·1	27	— 29	11	8·3	59
Adelaide	1014·1	— 1·0	109	44	82·4	56·4	69·4	+ 2·5	56·4	38	3·9	2	— 27	2	10·0	72
Perth, W. Australia	1014·3	— 1·0	97	47	75·8	56·9	66·3	+ 0·5	59·8	58	4·5	30	+ 10	9	8·3	61
Coolgardie	1011·6	— 1·5	102	46	88·8	58·0	73·4	+ 2·6	59·9	30	3·9	6	— 11	1	...	...
Brisbane	1013·2	— 1·1	93	60	83·8	65·7	74·7	+ 1·1	68·1	67	3·6	90	— 2	5	...	...
Hobart, Tasmania	1007·3	— 2·1	89	39	65·6	47·2	56·4	— 0·8	49·7	59	5·9	21	— 43	14	8·8	60
Wellington, N.Z.	1008·1	— 3·5	72	41	63·8	51·9	57·9	+ 1·0	53·3	74	6·7	138	+ 46	16	5·5	35
Suva, Fiji	1009·6	— 1·5	85	55	82·1	66·5	74·3	— 2·9	73·2	79	6·9	336	+ 94	13	...	...
Kingston, Jamaica	1013·0	+ 0·3	92	66	88·2	70·4	79·3	0·0	...	75	5·6	13	— 67	3	...	...
Grenada, W.I.	1011·0	+ 0·4	90	72	84·5	74·1	79·3	0·0	74·7	76	4·6	164	— 44	22	...	...
Toronto	1017·3	+ 0·5	61	21	46·7	34·8	40·7	+ 4·4	36·6	81	7·5	38	— 37	18	...	...
Winnipeg	1017·5	+ 0·8	54	6	38·4	26·1	32·3	+11·5	29·3	78	7·3	61	+ 37	10	...	...
St. John, N.B.	1011·9	— 2·0	49	19	39·5	28·9	34·2	— 2·5	31·5	80	6·7	63	— 49	11	...	...
Victoria, B.C.	1020·8	+ 5·3	56	36	48·5	39·7	44·1	— 0·3	41·1	90	6·3	49	—115	11	...	...

* For Indian stations a rain day is a day on which 0·1 in. (2·5 mm.) or more rain has fallen.

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